DRAFT

TECHNICAL MEMORANDUM 8
GEOPHYSICAL SURVEYING

SUMMARY
SITE INVESTIGATION AND REMEDIATION REPORT
AIRPORT/KLONDIKE AREA
AT
PRATT & WHITNEY
EAST HARTFORD, CONNECTICUT
EPA ID No. CTD990672081

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DRAWINGS

Acronyms

DC	Direct Current
DEP	State of Connecticut Department of Environmental Protection
DPH	State of Connecticut Department of Public Health
EM	Electromagnetic Terrain Conductivity
F&O	Fuss & O'Neill, Inc.
GPR	Ground Penetrating Radar
H&A	Haley & Aldrich, Inc.
LEA	Loureiro Engineering Associates, Inc.
M&E	Metcalf & Eddy, Inc.
MHz	Megahertz
MSL	Mean Sea Level
P&W	Pratt & Whitney
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
SOP	Standard Operating Procedure
TM	Technical Memoranda
VPSA	Virgin Product Storage Area

1. INTRODUCTION

1.1 Purpose and Objective

This Technical Memorandum (TM) presents the methodology and results of the geophysical surveying conducted in the Airport/Klondike Area (Site) of the Pratt & Whitney (P&W) facility located at 400 Main Street (Main Street facility) in the Town of East Hartford, Connecticut. Geophysical surveying using various techniques was conducted to:

- define the upper surface of the glaciolacustrine sediments in the South Klondike Area;
- to locate and determine the boundaries of former septic systems associated with the former Army barracks and training area located in the North Airport Area;
- to locate and determine the boundaries of former septic systems associated with former test stands in the Klondike Area;
- to determine the existence of the magnetic anomalies in the Airport/Klondike Area; and,
- to determine the depth to bedrock in the Airport Area.

1.2 Background

The Airport/Klondike Area is located on the eastern portion of the P&W Main Street facility on the east side of the main plant, north of Brewer Street and south of Silver Lane. The Airport/Klondike Area consists of four study areas that include the North and South Airport Areas and the North and South Klondike Areas. Previous investigations at the Site performed from 1990 through 1993 resulted in the installation and sampling of soil borings, groundwater monitoring wells and temporary wellpoints, surface water and sediment throughout the Airport/Klondike Area. Additional investigations have been conducted to define geologic conditions and anthropogenic structures at the Site which could impact contaminant transport and assist in conducting investigation activities.

1.3 Scope

This TM covers the techniques and methodologies of the geophysical surveying conducted in the Airport/Klondike Area. The methods and techniques discussed are those used by geophysical contractors and consultants during the period from approximately 1990 through 1996.

1.4 General Geologic and Hydrogeologic Conditions

The geologic and hydrogeologic characteristics of the Site are discussed in detail in the main body of this report. In general, the surficial materials, in which the majority of the monitoring wells are screened, consist of medium to fine grained sands with trace levels of fine gravels and coarse sands. These sediments are generally post-glacial, fluvial deposits associated with the Connecticut River, although in many places the upper portion of these sediments has been anthropogenically disturbed during on-site construction activities. Beneath the fluvial sediments are glaciolacustrine sediments, primarily laminated silts and clays, associated with glacial Lake Hitchcock. The basal sediment layer over most of the area is glacial till and stratified drift. Bedrock in the general East Hartford area consists of Triassic Age, interbedded arkoses and basalts. Bedrock in the area has a general slight dip eastward cut by widespread steep faults.

The regional drainage basin is the Upper Connecticut River Basin. Regional flow in the unconsolidated materials of this part of the basin is to the west, towards the Connecticut River. Local groundwater flow is also controlled to some extent by local drainage sub-basins and topography. The upper portion of the unconsolidated sediments serves as the primary aquifer in the area. Groundwater flow in the bedrock is primarily within fractures and fault planes, and to a lesser extent within the rock matrix. The local bedrock aquifer would be an adequate as a residential water supply source, but groundwater yields are typically too low to be of commercial or industrial use.

1.5 Geophysical Surveying Techniques

Various geophysical surveying techniques have been applied at the Site to provide different information regarding the nature of the surficial materials at the Site. These methods include seismic refraction surveying, electromagnetic surveying, ground penetrating radar surveying, and magnetometry.

Seismic refraction surveying consists of measuring the time it takes sound waves to travel through materials and relating that time to the nature of the materials. Seismic refraction surveying uses a system of vibration-sensitive receivers to detect and record sonic energy refracted from subsurface horizons. Seismic refraction surveying has been used in the Airport Area to define the depth to bedrock and the general nature of the unconsolidated materials.

Electromagnetic surveying consists of measuring the response of the geologic materials to induced electromagnetic fields. Electromagnetic surveying uses a coupled transmitter and receiver to induce and measure electromagnetic eddy currents in buried conductive objects.

Electromagnetic surveying has typically been used to locate areas where buried metallic objects may be located.

Ground penetrating radar (GPR) surveying consists of recording and converting radar signals reflected from subsurface materials. The GPR system transmits and receives pulsed electromagnetic energy and converts the received signals into indications of the change of the dielectric constants between subsurface materials or buried objects. GPR surveying has typically been used to located buried objects, such as pipes or tanks, that have significantly different dielectric properties from the surrounding soil.

Magnetometry is the measurement of variations in the normal magnetic field caused by the presence of buried magnetically susceptible objects. The magnetometry system consists of a magnetic field detector mounted on a staff to provide a constant height above the ground surface and connected to a recording device. Magnetometry is typically used to locate buried metallic objects.

2. METHODOLOGY

This section presents the general procedures and methodologies used to conduct and analyze the data from the various geophysical surveying techniques used in the Airport/Klondike Area. These methods were used by LEA, and also by previous consultants and contractors who performed geophysical surveying at the Site.

2.1 Seismic Refraction Surveying

Seismic refraction surveying was conducted on December 6 through 8, 1989, in the Airport Area by Weston Geophysical, Corp., as subcontractors to Westinghouse Environmental and Geotechnical Services, Inc.

Seismic refraction surveying consists of measuring the time-of-travel associated with compressional, or "P," seismic waves. The time-of-travel of the seismic waves can be related to the nature, composition, degree of induration, and degree of saturation of the material the waves are traveling through.

The seismic waves are generated by a "shot," or high-velocity acoustic wave generation event, at the "shot point," or the location of the shot. The shot can be generated by various sources such as air guns, hand-held drop weights, or small explosive charges. The waves are detected by vibration sensitive devices known as geophones. Geophones convert the seismic vibrations, or waves, into electrical signals and transmit those signals to a recording device through dedicated cables.

Interpretations of the geology are made from the analysis of the travel time curves which show the time required for each compressional seismic wave to travel from the shot point to the geophones. In general, velocity ranges of approximately 500 to 6,000 feet per second are indicative of unconsolidated sandy or gravelly materials. The lower velocity range is indicative of unsaturated materials with the seismic velocity range increasing with increasing saturation and density. Seismic velocity ranges of approximately 500 to 8,000 feet per second are indicative of clay units. Seismic velocity ranges of approximately 5,000 to 16,500 feet per second are indicative of consolidated rocks such as sandstone. Bedrock can have seismic velocities which span the entire range from that of unconsolidated sediments upwards, depending upon the type of bedrock and the degree of weathering and/or fracturing.

2.2 Electromagnetic Terrain Conductivity Surveying

Electromagnetic terrain conductivity (EM) surveying was performed on December 4 through 7, 1989, in the Airport/Klondike Area by Westinghouse.

EM uses a transmitter, or coil, to generate a magnetic field. The magnetic field induces eddy currents within the earth. The eddy currents produce secondary electromagnetic fields which are measured by a receiver coil. The strength of the secondary electromagnetic fields is related to the conductivity of the subsurface materials. The measured conductivity is the weighted cumulative sum of the conductivities from the surface to the effective depth of the instrument. The effective depth of the instrument is a function of the separation of the transmitting and receiving coils.

EM is useful for mapping of shallow conductive bodies, including conductive contaminant plumes, for the detection of buried bulk wastes, and for the detection of buried metal containers, including steel tanks and drums. However, EM is susceptible to interference from powerlines and surficial metals, and lacks vertical resolution compared to direct current (DC) electrical resistivity methods.

2.3 Ground Penetrating Radar Surveying

Ground penetrating radar surveying (GPR) was used on May 24 through 26, 1993 in the South Klondike Area by Fuss & O'Neill, Inc. (F&O), and on August 6, 1996 in the former Army Barracks Area, on August 12, 1996 in the X-312/X-314 Test Stand Area, on September 6, 1996 in the former Explosives Storage Area and Linde Gas/Chemical Storage Building Area, and on October 15, 1996 in the former Silver Lane Pickle Company Area by Kick Geoexploration.

GPR is a geophysical technique based on the transmission and reflection of short, rapid bursts of high frequency radio waves. In practice, a GPR system consists of an integral transmitter and receiver which are dragged on the ground surface along a transect. The transmitting antenna emits electromagnetic radiation at a frequency between 80 Megahertz (MHz) and 1,000 MHz, depending on the receiving antenna. The receiver records the reflected GPR signal strength. These data can later be transferred to plotting devices for graphic output.

In the subsurface, a portion of the electromagnetic energy is reflected back toward the transmitter when an interface between two materials with differing electrical properties is intercepted. The effectiveness of a buried object as a reflector is a function of the contrast between the electrical properties of the buried object and the sediments. The effectiveness of GPR to identify buried objects is also dependent on the electrical properties of the sediments. In general, conductive media such as silt and clay are effective GPR reflectors and thus limit the effective depth of the GPR signal. Less conductive sediments, such as sand and gravel, are less effective GPR reflectors and the effective depth of GPR signal penetration is much greater.

Interpretation of GPR is typically performed by visual inspection of the form and distribution of the reflected GPR signals. These data are translated into estimates of locations and interpretations of buried objects along the line of the GPR transect. When GPR is used to establish the geometry of the upper surface of a reflecting horizon, a combination of GPR and ground truthing is used to establish points on the reflecting horizon from which interpolations can be based. Ground truthing is the use of established depths, typically derived from borehole data, in conjunction with the GPR results.

2.4 Magnetometry

Magnetometer surveys were performed by Kick Geoexploration on September 6, 1996, in the former Linde Gas/Chemical Storage Building Area, and the Tie-Down Area, and on October 15, 1996 in the former Silver Lane Pickle Company area.

Magnetometry surveying uses a sensitive magnetometer to measure and record anomalies and variations in the prevailing terrestrial magnetic field. The surveying technique uses a detector attached to a staff so that the detector is maintained a constant distance above the earth during the surveying. The detector is attached to a recording device.

In practice, a local base station is chosen where there is minimal variation in the magnetic field intensity, and all measurements are reported relative to the magnetic intensity detected at the base station. During the surveying, magnetic measurements are made and recorded at locations along a predefined grid. These magnetic intensities are then plotted and analyzed to determine the presence of anomalies that may represent buried metallic objects.

2.5 Quality Assurance/Quality Control Procedures

Quality assurance/quality control (QA/QC) procedures used in performing the geophysical surveying varied depending upon the specific geophysical procedure used. For EM, the typical procedure was to perform functional tests of the instrumentation at the beginning of each work day, including checking the batteries, instrumental zero setting, instrumental sensitivity, compensation, and phase controls. In addition, background conductivity measurements were made at the beginning of each day in an area of the North Klondike identified as undisturbed.

The QA/QC procedures for GPR, magnetometry, and seismic refraction activities is limited to maintaining instrument calibration and performing proper instrument maintenance.

2.6 Decontamination of Materials and Equipment

Because geophysical surveying are not intrusive techniques, there is no need for decontamination between different transects or between different methods.

2.7 Waste Management

No wastes were generated by the geophysical surveying techniques employed at the Site.

2.8 Health and Safety

LEA field personnel conducted field activities in accordance with the LEA Site Health and Safety Plan that was prepared for all of the investigation activities included on the Site. In general, geophysical surveying was conducted in modified Level D personal protective equipment (PPE) consisting of safety glasses and surgical or nitrile gloves, and steel-toed shoes. Geophysical surveyors employed as subcontractors operated in accordance with their specific health and safety plans.

3. RESULTS

3.1 Seismic Refraction Survey

A total of 7,190 foot seismic refraction line was profiled along the eastern edge of the airport runway on December 6 through 8, 1989. The location of the seismic profile is shown on Drawing TM8-1. Based on overlapping geophone spreads, data sets from multiple seismic profiles were analyzed and correlated. An analysis of the seismic refraction data, based on seismic velocity only, was performed to characterize the thickness of the unconsolidated materials. Topographic elevation data from survey data and airport drainage plans was used to provide surface elevation data along the seismic line (Weston Geophysical Corp., 1990).

The seismic velocity data was separated into three groups, based on the relative degree of induration, the degree of saturation, and the composition of the materials present. The relatively loose, unconsolidated, unsaturated surficial materials had seismic velocities of 1,200 to 1,600 feet per second. Seismic velocities in this range are consistent with a variety of unsaturated sediments. These unsaturated materials, interpreted to be stream terrace deposits, were between 10 to 4 feet thick: thickest in the southwestern portion of the runway, where the water table is deepest, and gradually thinning toward the northeast.

Beneath the unsaturated materials was a layer characterized by intermediate seismic velocities of 4,850 to 4,900 feet per second. Seismic velocities in this range would be characteristic of saturated or clay-rich materials. This zone was interpreted to be saturated stream terrace deposits and glaciolacustrine sediments. These materials were interpreted as continuing to bedrock.

Beneath the zone of intermediate seismic velocities was a zone with seismic velocities approximately between 12,500 to 13,200 feet per second. This zone was interpreted to be bedrock. Seismic velocities in this range are consistent with those for sound sandstone or shale. These materials were not found to be of a defined thickness, that is, there was no additional underlying rock layer noted within the depth range of the seismic energy wave.

The bedrock surface, as interpreted from the seismic refraction profile, is approximately 277 feet deep in the southwest end area of the runway. The bedrock surface rises to a depth of approximately 135 feet within the first 3,000 feet from the southwest end area of the runway. Over the course of the next 4,190 feet of the seismic profile, the bedrock surface rises to a depth of 81 feet below the ground surface. The bedrock surface interpreted from these data is consistent with bedrock elevation data interpolated from test boring and production well logs for the East Hartford area.

There was no indication of a weathered or highly fractured zone in the upper portion of the bedrock. In addition, because of the range of seismic velocities observed, it was not possible to determine whether a zone of glacial till or stratified drift was present beneath the glaciolacustrine sediments.

3.2 Electromagnetic Terrain Conductivity Survey

EM surveys were conducted along eleven transects in the Airport/Klondike Area on December 4 through 7, 1989. During the survey, terrain conductivity measurements were recorded every 100 feet along the established survey lines. Also, measurements were continuously monitored so that conductivity anomalies could be identified. The location of the terrain conductivity surveys is shown on Drawing TM8-2.

The first terrain conductivity survey was conducted along the airport runway, along the same transect used for the seismic refraction survey. During the survey, a number of anomalies were recorded. With the exception of three, all of these anomalies were associated with subsurface conduits having surface expressions or being otherwise traceable. The three remaining anomalies were thought to be due to conduits, possibly drain pipes, which lacked surface expressions or could not otherwise be traced.

Two terrain conductivity survey lines were conducted in the North Klondike fill piles. Three conductivity anomalies were recorded from known sources, including two buried conduits and surficial steel drums. An additional oval-shaped anomaly, approximately 11 by 25 feet, was also noted to the west of the profile lines.

Two terrain conductivity surveys were performed in Fire Training Area "B" at the southern end of the airport. Several anomalies were reported from this area. One was reported to have been caused by a portion of steel drum partially buried in the soil. Three additional anomalies were reported to probably have been caused by a "tar-like substance" located on the surface.

One terrain conductivity survey was conducted west of the Virgin Product Storage Area (VPSA). Two anomalies were reported from this area. One anomaly was reported from west of Storage Area 2. The other was reported from near the southern end of the profile line, across from the McIlvane Property. No visible cause for these anomalies was reported.

Two terrain conductivity surveys were conducted near the northwest corner of the Klondike Area. The conductivity anomalies detected in this area were reported to probably have been caused by the pavement in the area, or a sewer line which crosses the area.

Two terrain conductivity surveys were performed in the Contractor Storage Area. South of Contractors Road, the terrain conductivity values were typical of background. North of Contractors Road, the conductivity values were considerably higher. These elevated measurements were considered possibly to have been caused by the presence of road salt from snow removal activities. The presence of salt could increase the conductivity of the soil moisture in this area.

One terrain conductivity survey was performed in the vicinity of the former Maintenance Building in the X-401 Area of the North Klondike Area. One anomaly, probably due to the building's septic system, was reported from this area.

In addition to the terrain conductivity profile lines, random surveys of various areas were conducted in the Klondike Area. An isolated conductivity anomaly was reported from east of the former X-412 Test Stand area. No possible cause of this anomaly was reported. Other scattered conductivity anomalies detected in the Klondike Area appear to have been associated with various underground piping or crushed steel drums, metals pans and other metal items associated with the fire training exercises conducted in Fire Training Area A.

3.3 Ground Penetrating Radar Survey

3.3.1 South Klondike Area

A GPR survey was conducted in the South Klondike Area on May 24 through 26, 1993, to determine the geometry of the upper surface of the glaciolacustrine sediments, typically referred to as clay, in the area and to provide information regarding the presence of septic systems in the area of the Cryogenics Building. A total of nineteen transects were performed with survey stations established every twenty-five feet for horizontal and vertical control.

Based on a combination of ground truthing and the GPR results, the elevation of the upper surface of the glaciolacustrine sediments was established southward from the Cryogenics Building to the southern end of the Virgin Products Storage Area (VPSA). Based upon the interpreted GPR signal transmission times, the depth to the clay surface ranges from approximately 10 to 18 feet below grade. As illustrated on Drawing TM8-3, the general surface of the clay ranges from an elevation of approximately 35 feet above mean sea level (MSL) in the area of the Cryogenics Building, to approximately 28 feet MSL at the southern end of the VPSA. The clay surface generally slopes from east to west-southwest, with slight surface undulations in the area of monitoring well SK-MW-14I.

Based on the GPR profiles, septic systems were located near the Cryogenic Building in the South Klondike Area. The locations of these septic systems are shown on Drawing TM8-3.

3.3.2 Former Army Barracks Septic Systems

A total of sixteen GPR transects were performed in the North Airport Area on August 6, 1996, to determine the presence and location of septic systems associated with the former Army Barracks. The location of the GPR transects is illustrated on Drawing TM8-4. In general, the location of the former septic system tanks and associated piping were located based on the interpretation of the GPR signals. In addition, "cell" structures, apparently related to the former septic systems were also located. Based upon an interpretation of the GPR signals, these cell structures appear to be composed of columns of undisturbed native materials separated by areas of homogenous fill material.

Possible former septic system tanks associated with the former 150-man and 100-man latrines, former supply and administration building, and former operations building, were located. Cell structures associated with the former septic systems of the 100-man and 150-man latrines, former supply and administration building, and the former leach fields associated with the 100-man and 160-man latrines were located. Various potential pipes were located throughout the area surveyed.

3.3.3 Tie-Down Area

A GPR survey was conducted in the Tie-Down Area in conjunction with a magnetometry survey. A variety of targets, described as " a scattering of miscellaneous objects, some similar to pipes" were interpreted from the GPR survey results. At the location of the magnetic anomaly, discussed below, a "tank-like form" was interpreted, but the structure was reported to have a 4-tiered structure with radar reflectors at depths of approximately 5.5, 7.5, 9.5, and 11.5 feet below grade. The long axis of the reflecting structure was reported to be oriented east-west.

3.3.4 Silver Lane Pickle Company

A total of three individual GRP surveys were conducted in the former Silver Lane pickle Company area. All of the surveys were performed to determine the presence of buried tanks in the area. At the southwestern corner of the area a prominent cylindrical object at a depth of 4 to 5 feet was detected and interpreted to be a large pipe. In the remaining two areas various objects were detected, but not reflections characteristic of a buried tank were interpreted from the results.

The results of magnetic surveying conducted in this area, discussed below, were generally consistent with these interpretations. However, the magnetic survey indicated the possible presence of buried tank in the northeastern corner of the area. There was no indication of a buried tank in the GPR survey results.

3.3.5 X-312/X-314 Test Stand Area

Approximately 900 lineal feet of GPR survey were conducted in the X-312/X-214 Test Stand Area. GPR signal penetration was reported at a few feet in the western portion of the transect to approximately 8 to 9 feet in the eastern portion. The difference in penetration was interpreted to be due to the presence of buried concrete rubble. A variety of buried radar reflectors were reported. These were interpreted to be due to possible large pipes or other buried debris. No reflections characteristic of buried tanks were noted.

3.3.6 Former Explosives Storage Area

A GPR survey consisting of approximately 300 lineal feet of transect was conducted in the former Explosives Storage Area. GPR signal penetration was reported to be approximately 13 feet. No GPR reflectors interpreted as consistent with buried tanks or pipes.

3.3.7 Linde Gas/Chemical Storage Building

A GPR survey consisting of a total of 300 lineal feet of transect was conducted in the Linde Gas/Chemical Storage Building Area on September 6, 1996. GPR signal penetration was reported to be approximately 9 feet. The results of the GPR survey were not reported except for the area surrounding the magnetic anomaly. No recognizable structures were interpreted from the GPR results in the area of the magnetic anomaly.

3.4 Magnetometry Survey

3.4.1 Tie-Down Area

A total of 72 grid node locations on approximately 10 foot intervals were surveyed. The data indicated the presence of various magnetic anomalies consistent with the presence of scattered buried metallic objects and steel-bearing rubble. One magnetic anomaly was interpreted to be consistent with that caused by presence of a buried tank. A GPR survey in the Tie-Down Area indicated the presence of a buried tank-like structure. The reported tank-like structure, as discussed in Section 3.3.3 above, displayed a 4-tiered structure with GRP reflectors at depths of 5.5, 7.5, 9.5, and 11.5 feet below grade, oriented east-west. No final interpretation of the structure was reported.

3.4.2 X-312/X-314 Test Stand Area

A total of 30 magnetic readings on an approximate 10-foot spacing were recorded from the X-312/X-314 Test Stand Area. The results were interpreted to indicate the presence of a "scattering of steel objects at the surface and buried." The report indicated that steel-bearing building rubble was visible on the ground surface in this area. There were no magnetic anomalies consistent with the presence of a buried tank noted in this area.

3.4.3 Silver Lane Pickle Company

The three area previously discussed under GPR survey results were also surveyed magnetically. The magnetic surveying results indicated a magnetic anomaly in the area of the southwestern corner of the area, consistent with a large pipe at a depth of 4 to 5 feet, and the possible presence of a buried tank in the northeastern corner of the area. GPR survey data did not indicate the presence of a buried tank, however.

An additional magnetic survey was conducted along the soil piles located in this area. No significant magnetic anomalies were noted during this survey.

3.4.4 Linde Gas/Chemical Storage Building

A total of 108 magnetic readings on an approximate 10-foot spacing were recorded from the Linde Gas/Chemical Storage Building area. The majority of the results were interpreted to indicate the presence of a scattering of buried debris, steel-bearing objects, or other structures, some of which were noted as visible on the surface. One anomaly, located near the former building footprint, was unexplained. A GPR survey in the area failed to detect any buried objects or other cause for the anomaly.

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DRAWINGS

US EPA New England
RCRA Document Management System
Image Target Sheet

RDMS Document ID # 2241

Facility Name: PRATT & WHITNEY - MAIN STREET

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Phase Classification: R-5

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Description of Oversized Material, if applicable:

DRAWING TM8-1: SEISMIC REFRACTION SURVEY RENTSCHLER AIRPORT LOCATION AND SECTION

[X] **Map** [ ] **Photograph** [ ] **Other** (Specify Below)

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DRAWING TM8-2: TERRAIN CONDUCTIVITY DATA, RENTSCHLER AIRPORT SUB-AREA LOCATION MAP

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Description of Oversized Material, if applicable:

DRAWING TM8-3: GROUND AND CLAY CONTOURS
SOUTH KLONDIKE AREA LOCATION MAP

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DRAWING TM8-4: GPR SURVEYS NORTH AIRPORT LOCATION MAP

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